

Pore Formation on InP Anodes in Alkaline Electrolytes

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Semiconductor structures with nanometer scale dimensions can result in drastic changes in the electrical and optical properties relative to those of the bulk material. The report of visible photoluminescence from electrochemically formed porous GaAs (1) has renewed interest in the localized dissolution of III-V semiconductors by anodization methods. The investigations of the anodic formation of porous InP have mainly been concentrated in HCl solutions (2,3). In this paper we report on the anodic formation of porous InP in alkaline solutions of KOH (pH 14.85) and (NH₄)₂S (pH 9.6). An advantage of the sulphide solution is in its passivating effects and with the reduction of surface states it may be possible to elucidate the real porous InP properties.

Cyclic voltammetric measurements were carried out on n-InP (100) in the dark in an (NH₄)₂S electrolyte. The initial potential was 0 V versus the saturated calomel electrode (SCE) and each electrode was scanned up to an upper potential, E_U , and back. The characteristic current-potential curves exhibit a small current peak on the forward scan (4). AFM imaging of the surface after anodization to $E_U = E_P$, where E_P is the potential of the peak current, revealed that small pores were randomly scattered over the area imaged. This illustrates the non-uniformity of the dissolution of the semiconductor under these conditions. When, $E_U = E_{MIN}$, (where E_{MIN} is the potential of the current minimum following the peak) a cross-sectional TEM image of the sample shows the formation of a passivating film covering the InP surface, as shown in Fig. 1., and indicated by 'A'. The pores propagate in the <111> direction, as indicated by 'B' and 'C'. The InP substrate is labeled 'D'.

Similar electrochemical measurements were carried out in a KOH electrolyte. It was found that the current at E_P was significantly higher in the KOH solution in comparison to the (NH₄)₂S solution (4). Fig. 2 shows a cross-sectional TEM image of a sample scanned up to $E_U = E_{MIN}$, where 'B' denotes the InP substrate. It can be seen that anodization in the KOH electrolyte results in a very porous layer being formed, as indicated by 'A'. This network extends approximately 500 nm into the substrate, thus accounting for the large current observed. Photoluminescence (PL) from the porous layer exhibited a red-shift in the emission spectra. TEM electron diffraction measurements indicate the presence of In₂O₃ in the pores. The red-shift in the PL spectra is believed to result from surface effects.

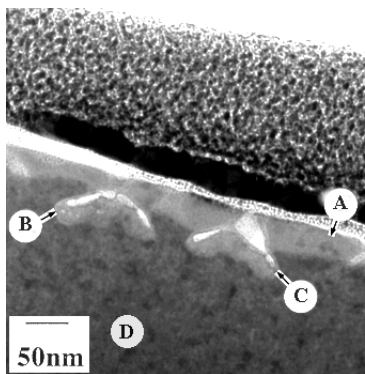


Fig. 1 Cross-sectional TEM image of n-InP after a cyclic voltammetric scan to $E_U = E_{MIN}$ in a (NH₄)₂S electrolyte.

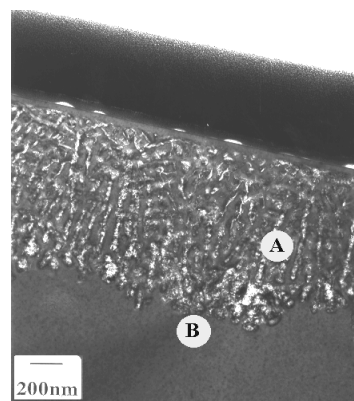


Fig. 2 Cross-sectional TEM image of n-InP after a potential sweep to $E_U = E_{MIN}$ in a KOH electrolyte.

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